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ABSTRACT

Investigating learning by imitation in infants and young children, this study addresses itself to the following issues: whether there is systematic accommodation, whether this imitation follows a universal sequence, how the development of an act over many trials relates to the development of indicators over many months, and what the phenomenon reveals about normal infant development in its social context. By meeting the gaze of the investigator, 34 infants elicited a rhythmic burst of 5 mouth movements, opening and closing. After many trials a majority of the infants themselves produced a burst of 2 or more such movements. Although no universal sequence of acts emerged from the data, a general form of accommodation was observed: (1) an orienting to the investigator, (2) a series of imitation of single features of the model, beginning with mouth movement, and (3) a string of 2 or more features of the model, before (4) integrating the features into bursts of mouth opening and closing. (Author/MS)

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FINAL REPORT

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LEARNING BY IMITATION IN INFANTS AND YOUNG CHILDREN

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Funds were insufficient to complete all three studies but Kaye and his students are still engaged in them on a larger scale (the small grant having served its purpose as "seed money"); one paper, by Kaye and Marcus, has already been completed and an ERIC abstract is attached.

ERIC ABSTRACT

"Imitation in stage III or IV"

The 6-month-old infant is capable of superior imitation when he or she controls the timing of the model presented. By meeting the gaze of E, 34 infants elicited a rhythmic burst of 5 mouth movements, opening and closing. After many trials a majority of the infants themselves produced a burst of 2 or more such movements. Although no universal sequence of acts emerged from the data, a general form of accommodation was observed: (1) an orienting to E, (2) a series of imitation of single features of the model, beginning with mouth movement, and (3) a string of 2 or more features of the model, before (4) integrating the features into bursts of mouth opening and closing.

Imitation in Stage III or IV

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Imitation in Stage III or IV

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If an infant about 6 months of age is presented with a relatively novel sequence of movements, he or she is unlikely to imitate the movements with much precision. To be sure, a smile will often elicit a smile, and a shaking of the head or arms will often elicit a shaking of the arms or head. But the form of the infant's immediate response is not particularly matched to the form of the model; it is difficult to distinguish the form of responses after the model's presentation, from similar movements produced by the infant spontaneously in the absence of a model. Furthermore, it is easiest to increase the frequency or intensity of movements in which one happens to find the infant already engaged. Thus immediate imitation in this period of development looks very similar to what Baldwin (1895) called the secondary circular reaction. When we test the infant by only one or two presentations of the model, we see no evidence for covert representation of action schemas. On this basis Piaget (1951, 1952) defined stage III of sensory-motor development: the stage of secondary circular reactions. He noted that his infants did not accommodate their actions to his modeling unless the modeling was similar to their own immediately preceding behavior, and unless they could see themselves making the movements.

The facts are very different if one changes the procedure in two ways. By allowing the infant to control the presentation

of the model--for example, by initiating a sequence of mouth movements every time he or she makes eye contact with the experimenter--and by continuing for dozens of trials, we can get 6-month-olds to make significant accommodations to a model, even when they have no visual feedback from their own movements and no other form of feedback from the model.

The basic phenomenon, the elicitation of striking degrees of imitation simply by allowing the infant to alternate his or her own attempts with repeated observations of the model, can be found with hand movements of various kinds, vocalizations, rhythmic activities, and even sensory-motor problem-solving tasks. The inspiration for trying this method came from a variety of sources: the imitation literature (Valentine, 1930); observations of alternation between responses such as looking and sucking (Bruner and Bruner, 1969); studies of face-to-face dialogues between mothers and infants (Brazelton, Koslowski, and Main, 1974); and our own observations of turn-taking (Kaye, 1970, 1971, 1976a, 1976b). This study deals with one example of the phenomenon: the imitation of mouth movements the infant cannot see himself make.

It is fairly well established that infants even in the 1st month of life will reliably respond to movements of an adult's tongue or lips, with movements of their own tongues or lips. This has been noted by Moore and Meltzoff (1975), Uzgiris (1972), and Maratos (1973), and is a common experience of many who have interacted with young infants. Preyer (1889)

and Guillaume (1971) noted a decline in this sort of nonspecific mouthing imitation between the 2nd and 7th months. While it may well be important that such a response in the first few months of life should have evolved in a species for which the mouth later plays several crucial social roles, it is no more remarkable than other neonatal reflexes or, for example, the pecking response of a herring gull chick to a red spot on its mother's beak (Tinbergen, 1961). Although the response elicited in the case of the human infant happens to resemble the stimulus, there is no accommodation of the young infant's mouthing to that of the adult.

In the present data, on the other hand, at age 6 months, there appears to be accommodation to the model. The study was designed to address four issues:

(1) Is there indeed systematic accommodation? Although our informal observations convinced us that infants at this age gradually approximate the form of the model over a series of trials, it is also true that not every trial is an improvement over the previous one. We hoped to quantify the degree of match to the model, and also to discover whether the infants' attempts progressed systematically through some fixed sequence. In other words, did infants add features of the model to their own schemas in any consistent order?

(2) Whether this imitation follows a universal sequence or is idiosyncratic, how does the infant do it? The more one observes the phenomenon and thinks about it, the more difficult

it is to explain. The infant receives no information as to the adequacy of his or her match to the model. Any feature of the model which is selected for imitation is experienced visually but then produced without any visual feedback. Later in this paper, we shall consider whether this selection of features is an active process: whether the infant is testing an hypothesis. Or, as a very different but equally startling possibility, is the whole set of possible features of mouth movements somehow pre-programmed for imitation? We shall argue that the explanation lies somewhere between these untenable extremes.

(3) How does the development of an act over many trials relate to the development of imitation itself over many months? Studies attempting to elicit imitation of various kinds of activity at different ages (Uzgiris, 1972; Maratos, 1973) may reveal the relative difficulty of the various tasks but should not be interpreted, even normatively, as reflecting cognitive limitations in the infant. Changing the method of presentation of the model, giving the infant time in which to respond, and continuing for many trials can yield much more impressive results. However, it may be the case that the sequence of accommodation over trials, if indeed there is a consistent sequence, corresponds to the sequence of types of immediate imitation through which the infant progresses over the course of a year or two.

(4) Does the phenomenon tell us anything about normal infant development in its social context? We shall turn to this final

question in discussing the results of this study. Imitation in infancy has traditionally been investigated as though it were only a matter of the infant's mental growth. In our view, imitation is among the quintessential human social activities, and both its development and its evolution must be understood in this context.

METHOD

Subjects in this study were 40 Caucasian infants between the ages of 26 and 28 weeks. All 21 male and 19 female infants had been delivered in Columbus Hospital, Chicago, without complication and after normal full-term pregnancies. They and their mothers were participants in a longitudinal study which began in the 9th month of pregnancy. The project involved observations in the hospital as well as 4 visits to the home, at 2, 6, and 13 weeks and the one at 26 weeks. Almost without exception the senior author had seen the infant and mother either at the hospital or the 2-week visit, and at none of the other visits. He was therefore a stranger to the infant, and the following procedure came at the beginning of the session before he had interacted with the infant in any other way.

The investigator (E) walked slowly toward the mother who held her baby facing him. As he took the infant, the mother moved 10 to 20 feet away (depending upon the arrangement of the home) so that she would not be a distraction. E sat in a straight chair with the infant in his lap, held

under the arms and facing him. Each session was videotaped with a camera 6 to 8 feet to E's right, capturing slightly less than a profile of his face and slightly more than a profile of the infant's face when they were looking directly at one another. Using a Zoom lens, the cameraman located the area bounded by the front of E's face, the infant's full head and upper body, and the infant's hands. From time to time within each session the cameraman sacrificed hand movements for the sake of a larger image of the infant's face.

For the first 2 minutes (less if the infant verged on crying), E engaged in normal, flexible interaction and vocalization. He responded to vocalizations or social expressions, initiated smiling, and in general attempted to gain and maintain the infant's attention. At the end of this "baseline" period he dramatically altered his behavior. Whenever the infant's eyes met his, he immediately made a series of 5 open-and-close mouth movements, like a goldfish, with a slight popping sound. Visually this display looked identical to "MA-MA-MA-MA-MA" without the vocalization: its duration was 3.5 seconds. Every time the infant's gaze left E's eyes and returned (so long as it returned after E had completed the whole series), he repeated the model. Sometimes the first 1 or 2 trials required calling the infant's name or jiggling his body to get him to make eye contact. Otherwise, and for all subsequent

trials, he refrained from smiling, talking, etc. Although the timing of his behavior was controlled by the infant's eye movements, its form was in no way contingent upon any aspect of the infant's behavior. Trials continued so long as the infant cooperated; the maximum number was 63 trials, which took 9.3 minutes, and the median number was 20.

We will describe the typical response of babies to this procedure in the following section. It should be mentioned here that all subjects clearly caught on to the turn-taking game, and to the fact that the adult's behavior was under their control, within 1 or 2 trials. By the 3d trial and thereafter, they simply flicked the model on by a quick eye movement and then looked at E's lips in anticipation of the stimulus. Six subjects were dropped from the analysis, however, because intense crying during the baseline and/or 1st and 2nd trials led the E to terminate the session.

The videotapes were coded by the junior author, who had not seen any of the subjects, data, or videotapes of earlier visits. Our unit of analysis was a "trial." Each trial began when the infant met E's eyes and triggered a stimulus presentation, and ended when the next trial began. The following coding procedure facilitated sequential analysis across trials but not within trials.

The coder watched until an event in Table I occurred; she then stopped the videotape to record. While transcribing mouth movements, vocalizations, smiles, tongue movements, and drools, the coder was not able to attend to other body movements.

To record them, she viewed the videotape a 2d time. Timing the durations of the baseline and trials was done at a 3d viewing.

Table I goes about here

Marcus (1976) details our analysis of data with respect to the 27 behavioral categories in Table I. For the present analysis, all types of mouth movement (categories 1-10) were collapsed into one category and summed for each trial. Rhythmic bursts were collapsed into 3 categories: mouth bursts (23), vocalization bursts (27), and non-oral bursts (24-26). Of the remaining categories, only open-and-close hand movements were included in this analysis.

To establish coding reliability, the junior author trained 2 other coders. One was trained before the actual coding began, and the other (E) was trained when coding was nearly completed. At this time, the junior author also recoded 3 videotapes which she had done 2 months earlier. Five videotapes were randomly selected for measuring intercoder reliability with the 2 extra coders. Percentage of agreement was the ratio of the number of occurrences agreed upon by both coders to half the total number of occurrences (i.e., the mean) recorded by the 2 coders. Both Intracoder reliability (showing that categories were maintained through the period of coding) and intercoder

reliability ranged between .87 and 1.00 for different variables, when occurrences were defined in a yes-or-no fashion on each trial.² Agreement as to whether there were ⁴ mouth movements or ⁵ on a given trial, etc., were in the range .70 to .85. Agreement for a few fine categories such as "within resting" was unacceptably low.

This coding system was difficult. How short an interval between movements was short enough to comprise a burst, and how much parting of the lips constituted the "rest" position for one subject as compared with another, were matters of intuitive judgement. There is no question that many events were missed, including those which simply occurred off-camera. The phenomena we observed live and on videotapes were robust enough to surface in the data despite these sources of unsystematic error.

RESULTS

The stimulus presented consisted of (a) a rhythmic burst of (b) ⁵ (c) open-and-close movements (d) of the mouth, (e) with a popping sound. We define imitation as the occurrence of any of these features, singly or in combination, at a higher rate than during the baseline. Accommodation suggests something more: a systematic improvement in the match over trials. Whether anything is learned as a result is a still further question, not asked in the present study.

Since no vocalization accompanied the stimulus, vocalizations were not considered to be imitations of features of the model;

however, bursts of vocalization were grouped with bursts of arm movements, self-adapting movements, etc., as imitating the rhythmic-burst feature.

The right-hand columns of Table II indicate the numbers of subjects reaching criteria, with the median trial numbers by which they did so. Roughly two-thirds produced a mouth

Tables II and III go about here

burst (combining features a, c, and d) on at least one trial. Ten of these 22 subjects repeated it on 3 or more different trials. Table III shows the rates of each type of behavior during the modeling trials as compared with the baseline. Statistical significance in each case was based upon a t-test matching every subject's baseline rate against his or her average rate over all modeling trials.

There were some changes in the rates of occurrence of each category over trials, but these were inconsistent. Accommodation to a model need not be reflected in a linear increase of rate with which some feature of the model is imitated, since once a constituent is mastered there may be no need to practice it while attending to other features. We were particularly concerned to find any consistent sequence of events between the 1st trial and a "successful" imitation, a mouth burst. A reasonable way to simplify the data for this purpose was to look only at the 1st occurrence of each category. The order in which categories 1st occurred is shown in the left-hand columns of Table II.

It is clear that the most salient feature of E's modeling was that his mouth was moving. Only 12% of subjects produced open-and-close hand movements or non-oral rhythmic bursts on a trial preceding their first mouth movement. This is not completely surprising since mouth movements were fairly frequent on the baseline. The rate of mouth movements became significantly higher once the trials began (Table III) but we cannot say that the very first mouth movements on trial 1 were necessarily imitation.

As second steps, there were alternative paths taken by different infants. Some progressed directly to mouth bursts, as shown in Table II. Some made rhythmic bursts of arms, vocalizations, or self-adapting movements. Open-and-close hand movements, if seen at all, tended to come later.³ Only 3 subjects actually followed the full sequence (mouth movement--rhythmic burst--open-and-close hand movements) and none of these ever produced a mouth burst. One subject introduced all 3 features on the 1st trial, and did produce a mouth burst on trial 12. In short, the typical infant imitated mouth movements immediately, then imitated one or both of the other main features of the model, but neither of these was obligatory. In fact, 8 subjects produced their 1st rhythmic bursts and 8 produced their 1st open-and-close hand movements after their 1st burst of 2 or more mouth movements.

A particularly striking observation on many of our videotapes is the combination, on the same trial, of non-burst

mouth movements and non-mouth rhythmic bursts. These are usually paired sequentially rather than simultaneously, as though the infant were saying "mouth-burst" or "burst--mouth." The data show that trials containing rhythmic bursts average just over 3 mouth movements ($N=26$ Ss, 161 trials) while the same subjects' other trials average fewer than 2 mouth movements ($t=2.62$, 24 d.f., $p < .02$). Examination of the data showed that vocalization bursts were rare and could not have accounted for this juxtaposition of mouth movements with non-mouth rhythmic bursts. With respect to open-and-close hand movements, there was neither a tendency toward juxtaposition with the other features, nor any mutual exclusion.

The number of beats per burst was an additional feature of the modeled behavior. When infants' mouth movements met the criterion for bursts, the number of beats averaged 3, fewer than E was modeling. There was no consistent increase over successive mouth bursts. The average number of beats in other rhythmic bursts was also 3, and again this mean neither increased nor decreased over trials. However, there was a great deal of variability both between and within subjects in the number of beats per burst. We are not confident of the reliability of these counts; bursts tend to trail off so that a 4th, 5th, or 6th beat may be so delayed as to be of questionable standing.

We explored differences between the 12 infants who did not reach the "mouth burst" criterion, the 12 who did so on 1 or

2 trials, and the 10 who achieved mouth bursts on at least
3 different trials. Differences emerging from comparisons
of the rates of each type of behavior were consistent with our
subjective impressions, and are being examined further in our
current work. The less successful infants seem to have been
those who responded in a social manner to E, expressing their
excitement in self-adapting activity and in more smiling
even during the baseline. The more successful were those who
quickly became still when the trials began and focussed upon
features of the model. Although less active during trials,
their activity was more varied. It was not unusual for an
infant to try 3 or 4 different kinds of rhythmic burst, as
well as successful mouth bursts.

A general picture of infants' behavior in the situation is
better acquired by viewing our videotapes or replicating the
procedure with 1 or 2 subjects of one's own. We present
a brief summary here. The infant's behavior changes instantly
with the onset of the 1st modeling trial. There is orienting,
stilling, a quizzical facial expression. By the 2nd or
3rd trial the infant shows clearly, by anticipatory eye
movements, that he or she is intentionally controlling the
stimulus. While E is producing the stimulus, the infant is
typically still; trials on which the infant starts to act before
E has finished are exceptional, and so are trials on which the
infant triggers the next trial before becoming still again.
Trials vary in length. There are sequences of short trials
in which the infant does nothing but elicit the model several

times; there are trials in which the infant's turn is about as long as E's; and there are longer trials in which the infant runs through more than one imitated feature. During these longer trials he appears to be carefully avoiding looking at E. Prolonged gaze aversion (20 seconds) is usually a good indicator that the session might as well end, though a few infants will later attempt to elicit the stimulus again.

The foregoing paragraph describes what will be observed using our procedure with any of a variety of modeled actions. With a mouthing pattern similar to the one used in the present study, the 1st behavior seen will usually be isolated mouth movements. Within a few trials mouth movements will be accompanied by rhythmic self-adapt movements or arm beating, sometimes bursts of vocalization, pulling on the dress, and/or open-and-close movements of the hands. These latter often take the form of clutching or scrabbling against a surface or against the infant's own body. Eventually there will be a convincingly imitative burst of mouth movements, but the other actions will continue on subsequent trials.

DISCUSSION

Is there systematic accommodation? We did not find a standard sequence of imitated features through which infants progressed toward more perfect imitation of the model. Nearly all infants responded quite early with mouth movements not particularly matched to the form of the model. Some, before producing bursts of open-and-close mouth movements, tried

bursts of grosser activity such as arm beating or vocalization; and/or they tried opening and closing their fists. Six subjects produced at least one mouth burst containing exactly 5 beats to match the model, but no infant converged on the number 5 and stayed there convincingly over successive trials. Only one infant imitated the sound associated with E's modeling, as shown in Table II.

At a more general level, it is possible to distinguish phases in the typical infant's response over trials: (1) an orienting to E, stilling of the body, and checking to confirm that his or her eye movements really are sufficient to control E's behavior; (2) a series of imitations of single features of the model, beginning with mouth movement; (3) a combination of two or more features, sometimes beginning with sequential combinations before (4) integrating the features into bursts of mouth opening and closing. In short, individual infants appear systematic in their active imitation of features of the model, though there is no universal sequence with respect to those features.

How does the infant do it? In this procedure there is no reinforcement of imitation, and E responds in no way contingently upon the infant's mouth, arm, hand, or body movements or vocalizations. As for the Infants' prior experience it would be unreasonable to suppose that they had been reinforced for making mouth movements similar to ours, in response to the particular arbitrary pattern we chose. All of the mothers were quite astonished by E's behavior in this study. Some

reported playing games in which their infants would imitate some action or sound (such as saying "AAAH") but the behavior cited was never similar to the pattern used by E.

Covert representation of the stimulus pattern does not play a part in the infant's performance. On the contrary, we are seeing the overt accommodation of a schema, such as will only later be internalized. Other evidence for representation, such as deferred imitation, is not seen at 6 months. However, one of the earliest steps toward representation, recognitory assimilation (e.g., when the infant shows recognition of his grandmother by initiating a particular pat-a-cake game which they have played), does begin some time between 6 and 9 months. If we take as one of the defining criteria of representation the ability to imitate novel acts immediately (Piaget, 1951), which is not seen until some time in the middle of the second year, we can regard the slow accommodation seen in the present study as an early form. In other words, when the child "has" representation we really mean that he has representations and the ability to use them in immediate imitation, in imitating absent models, and in play; but earlier, at 6 months, we already see the active process of re-presentation in the overt accommodation of schemas.

Are we saying the 6-month-old "knows" what he or she is doing? In the first place, to invoke consciousness of this accommodation in the infant would have no explanatory value. If he knows what he is doing in any sense we still have to explain where he gets the relevant information. It is, however,

worth comparing the behavior of our subjects with that of considerably older subjects in whom Piaget (1976) has studied "cognizance" of their own actions. Cognizance involves conceptualization, and the child's regulation of his action with concepts is manifested by discrete changes. What Piaget calls "reflexive abstraction" is actually observable. The child either registers success or halts at points of mismatch between action and concept. This is precisely what we do not see at 6 months. The infant's behavior remains a continuum, its fluctuations over trials being a matter of noise in the system, without any qualitative discontinuities or irreversibility. However, the direction of that continuum is from isolated features of the model to means of assimilating those features to one another; this corresponds to the direction of progress in conceptual consciousness, from the periphery of action and object to the center, or coordination of movements (Piaget, 1976); or in Bernstein's (1967) terms from 1st-wert and sol-wert to delta-wert. The working out of this basic direction first on the plane of automatic regulation of the infant's own movements--before regulation with objects, before representation, and before conscious conceptualization--is entirely consistent with Piaget's recent theory.

The way our subjects progressed through different features of the model is somewhat reminiscent of a stochastic theory which Piaget (1950) once offered to account for the development of conservation and perceptual illusions. To illustrate with our present data, we could say that mouth movements have

a very high probability of being elicited by mouth movements, rhythmic bursts have a somewhat lower probability of being elicited by rhythmic bursts, etc. The joint probability of the infant's attending to these several features and imitating them together would initially be very low but would increase as the frequency of imitation of the separate features increased. Such an account is inadequate to deal with our data, probably for the same reason it is inadequate with respect to the later operational accomplishments: the separate probabilities are in fact never independent. The limited attentional capacities of the infant, as well as limited motor control, necessitate separate practicing of constituents until, as Bruner (1973) argues, sufficient attention can be freed for working on other constituents and eventually on their combination. Our subjects imitated separate features; these might then drop out but (far from having been extinguished by E's non-response) might later reappear in sequential combinations. Eventually, by reciprocal assimilation the features would reappear in an accommodated schema. We have described this sequence above: (mouth movement) . . . (rhythmic arm or body or vocalization burst) . . . (open-and-close hands) . . . (mouth movement, other rhythmic burst) . . . (rhythmic mouth open-and-close burst).

For an infant to progress through this sequence would presuppose that the constituents, in some form or another, had at least a basic probability of imitative occurrence. Piaget(1951) traces the development of schemas such as rhythmic

arm and hand movements, etc., out of primary circular reactions. The observations which Maratos (1973) reports of early "imitated" head movements are of this kind; they begin as visual tracking of the adult's face, and as a prolongation of the sensations which result when the adult's head is moving.

Imitation is usually defined in terms of a heightened probability of occurrence of some act, as in the present study, rather than as the appearance of an absolutely novel event. The latter, of course, one never sees. In the example just cited from Maratos's study, the infant's head movements can be called imitative because they resemble the model and their rate of occurrence is significantly increased by the model. Yet they are easily explained as a result of visual tracking, and possess none of the attributes which make later forms of imitation so problematic for psychological theory. One can make a similar statement with respect to our own research on early feeding. Rhythmic oscillation sometimes appears to be transmitted from the infant's burst of sucking, to the mother's jiggling when he pauses, back to the infant's sucking (Kaye, 1976b). In this case the fact that the infant would suck in a cyclic burst-pause pattern anyway, even if his mother did nothing, prevents our calling this neonatal behavior imitation. The complexity of mother-infant interaction in our species is indeed remarkable in the first days of life; yet it is initially provided as preadapted responses in the two partners.

So it is with the fact that the newborn comes equipped with a reflex linking the sight of normal human mouth movements to

completely unaccommodated mouth movements of his own. What happens at 6 months can be understood as the natural extension of a process which begins much earlier. All the features of our "mouth burst" are available to the infant through assimilation of schemas he can observe himself enacting, except one. The missing feature, the link between the sight of a moving mouth and the kinesthetic sensations of his own mouth, is given him as a birthright.

Our study shows, then, in general, how various primitive forms of imitation without accommodation first come together to allow accommodation by reciprocal assimilation, even in the absence of external feedback.

How does imitation itself develop? The recent literature on imitation in the first 2 years of life suggests that it is a matter of a basic ability gradually spreading over more and more complicated tasks (Uzgiris, 1972; Maratos, 1973; McCall, 1975). For example, one can get a large proportion of 10- to 12-month-olds to imitate simple movements of their own body, but one must wait a few weeks for more complex movements or movements they cannot see themselves make. One must wait longer for tasks involving

multiple relations among objects than for simple object-directed acts, etc. In general these studies (and the limited way imitation has been investigated in connection with language development) give the impression that the child imitates just those kinds of action in which he spontaneously engages at any given age.

Without denying that the kinds of behavior which can be imitated expand in number and complexity with the infant's sensory-motor development we would make three further statements: (1) Imitation itself develops in speed and efficiency. While accommodation may be said to be an invariant function, its mechanisms make enormous progress from reciprocal assimilation to means-end experimentation to representation to cognizance. In addition, the infant's attentional capacity and motor control develop. The developmental course of imitation is to a large extent a matter of the speed and efficiency with which various behavior can be imitated, and this is not apparent when we stop our experiment after one or two presentations of the model. (2) Imitation and accommodation depend also upon the building blocks or schemas available to the infant in his repertoire. This is perhaps obvious, but it has a less obvious implication in that limits upon the complexity of behavior imitated by the young infant may be due to the small number of schemas at his disposal rather than to the constraints of complexity itself; or it may be due to both. (3) The study of immediate imitation tells us little or nothing about how

imitation is being used by the infant or child at a given stage, at the frontier of developing schemas.

We hypothesized that the sequence of features 6-month-old infants would imitate, in the course of many trials alternating with our presentation of a standard model, might correspond in some way to the sequence of acts which increasingly older infants are able to imitate immediately. This might still be a viable hypothesis where one finds a universal sequence of features over trials, but with the "goldfish" mouthing pattern we did not find a sequence of that kind. Instead the trials could be grouped into more general phases, and these indeed remind us of the sensory-motor stages through which Piaget's infants progressed (1951). On the first few trials our subjects look like stage II, in which reflecting an infant's own behavior (mouth movements) back to him can result in an increased rate of the behavior and a kind of turn-taking with the adult. After a few more trials the same subjects look like stage III or IV, in which schemas from their own repertoires are activated and variations are introduced. Eventually when a convincing mouth burst has been achieved by the infant, all that distinguishes his imitation from that of stage V is the amount of time and effort that has been required to produce it.

What about normal interaction? Although our interaction with the subjects was especially controlled and would never be found in nature so idealized, without vocalization, digression,

inconsistency, etc., it was nonetheless derived from observations of normal parent-infant interaction, and it worked. Structured procedures designed for interaction with infants do not work unless they fit the design of the organism. This procedure works because infants are designed to interact with adults by turn-taking, by controlling the timing of the adult's behavior, and by juxtaposing observation of models with imitative attempts. As indicated, these subjects were part of a longitudinal sample; we hope eventually to relate their behavior in this study to our observations of their interaction with mothers and fathers (Kaye, 1977). On the basis of the preceding discussion, we can suggest two ways in which the preceding 6 months of interaction probably help to prepare the infant for our experiment. First, the number of times his or her mother has imitated the infant's own mouth movements is surely in the hundreds, especially from the 4th month with the introduction of solid foods and the increase in face-to-face games. She has at the same time elicited more mouth movements. Both these activities may help to keep potent the basic mouthing-imitation reflex. Second, turn-taking and contingent games of other kinds have been developing for months. Since the smoothness and success of these forms of interaction seem to distinguish different dyads, we can hypothesize that in our longitudinal study individual infants' experience as assessed from our videotapes of mother-infant interaction will predict the smoothness and success of their imitation of the stranger.

SUMMARY

The 6-month-old infant is capable of superior imitation when he or she controls the timing of the model presented. By meeting the gaze of E, 34 infants elicited a rhythmic burst of 5 mouth movements, opening and closing. After many trials a majority of the infants themselves produced a burst of 2 or more such movements. Although no universal sequence of acts emerged from the data, a general form of accommodation was observed: (1) an orienting to E, (2) a series of imitation of single features of the model, beginning with mouth movement, and (3) a string of 2 or more features of the model, before (4) integrating the features into bursts of mouth opening and closing.

Footnotes

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2. Reliability was sometimes lower on a particular videotape, when the number of occurrences was low. If an event actually occurs 3 times and is seen only twice by each coder, agreement for that session may be 1.00 if the same 2 instances are seen but only .50 if each coder misses a different 1 of the 3.
3. This may be an artifact of the videotaping procedure. Open-and-close movements of at least the left hand were always visible if they occurred on the baseline, but the camera zoomed closer for imitation trials and sometimes missed the true 1st occurrence of hand movements. Both how soon the 1st open-and-close movement occurred and the frequency of such movements during trials were thus underestimated.

Table I: Coding Category Definitions

(All of the following categories are mutually exclusive as they occur, and are recorded in sequence within each trial.)

- 1-5 Movement into one of the following positions from another position:
- Closed--lips pressed together in a line, without puckering
- Rest--mouth open, relaxed
- Intermediate--mouth somewhat widened; teeth (if any) visible
- Wide--looks capable of swallowing a ping-pong ball
- Puckered--mouth rounded, lips creased in a circle
- 6-10 Movement within any of above positions
- 11 Fingers--fingers or hand to mouth, no visible mouth movements
- 12 Cheek movements
- 13 Hide--mouth cannot be seen due to head movements away from the camera or other obstruction.

(The following categories can occur simultaneously with those above.)

- 14 Smile--bright smile (not counted also as mouth movement)
- 15 Tongue--tongue visible between lips, need not protrude
- 16 Vocalizations--with or without mouth movement; excluding cries
- 17 Crying or fussing--presence on trial rather than discrete cries
- 18 Drooling--presence on trial, not discrete drools

Table I continued

(The following categories are coded on a second viewing of the videotape.)

- 19 Self-adapts--all gross movements of the body including tensing-relaxing, extension, bouncing, twisting, leaning, head lowering, arching, and jerking.
- 25 Arm and hand--coded only when occurring in bursts (see below)
- 20 Reach to E--attempt to touch E's face, arm, or shirt
- 21 Open-and-close--opening and closing, or closing and opening at least 4 digits of either hand in a continuous movement
- 22 Hand to face--subject touches own face, ears, nose, etc.

(The following information is coded in conjunction with certain of the preceding events.)

- 23 Mouth bursts-- 2 or more pairs of opening and closing movements of the mouth within any position or from one to another
- 24 Self-adapt bursts-- 2 or more identical gross body movements in rapid succession
- 25 Arm and hand bursts-- 2 or more gross articulations such as pounding, tapping, or flailing, in rapid succession
- 26 Open-and-close bursts-- 2 or more hand movements as defined in item 21, in rapid succession
- 27 Vocalization bursts-- 2 or more vocalizations in rapid succession

Table I continued

28-32 Beats--the number of beats (2 or more) in each
burst

Table II: Subjects Imitating Features of the Model (N=34)

Number of and order in which subjects imitated feature

Feature	as 1st feature imitated	tied for 1st (same trial)	as 2nd feature imitated	as 3rd feature imitated	as 4th feature imitated	total	% of N	median trial of 1st occurrence
(d) Mouth Movement	21	2+2+5 ↑ ↑ ↑	3	1		34	100	1
(a) Rhythmic Bursts	3	5+1 ↓ ↓ ↓	7	9	1	26	76	4
(c) Open-Close Hand	0	2+1+1 ↓	1	7	4	16	47	9
(acd) Mouth Burst	0	2	12	5	3	22	65	10
(e) Popping Sound	0		0	0	1	1	3	16

Table III: Mean Rates of Occurrence (per minute)
during Baseline and Trials (N=34)

Feature	Baseline		Trials		Matched t-test	
	mean rate	S.D.	meanrate	S.D.	t (33)	p <
Mouth Movements	5.135	3.216	9.963	5.726	5.10	.001
Rhythmic Bursts	.643	1.008	1.467	1.406	3.53	.01
Open-Close Hand	.364	.853	.698	1.263	1.40	N.S.
Mouth Bursts	.058	.195	.527	.799	3.40	.01

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